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DEPARTMENT OF REGISTRATION AND EDUCATION
DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*

REPORT OF INVESTIGATIONS—NO. 22

REFRACTORY CLAYS IN CALHOUN AND PIKE COUNTIES, ILLINOIS

BY

J. E. LAMAR

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REFRACTORY CLAYS IN CALHOUN AND PIKE COUNTIES, ILLINOIS

By J. E. Lamar

INTRODUCTION

The clay and clay products industry is Illinois' second largest mineral industry and its pits and plants are widespread throughout the State. Calhoun and Pike counties, however, have but small representation in this extensive industry, despite their large and varied clay resources. It is the purpose of this report to call attention to the clay resources of these counties, particularly fireclays and recently discovered deposits of flint clay.

Detailed and reconnaissance data concerning clays in these counties have been accumulating for some years. Although the information at hand is not sufficiently complete to permit a detailed report, the current interest in refractory clays make it desirable that this data be published in order to render all possible assistance in outlining and developing the western Illinois deposits.

ACKNOWLEDGMENTS

Mr. W. A. Guthrie of Nebo and Mr. W. G. Marqua of Pleasant Hill willingly assisted and cooperated in the study of the clays of the Howell Hollow and Sixmile Creek areas and furnished many outcrop data, results of borings, and ceramic and chemical analyses of a number of clay samples, except as otherwise stated in the discussion of the Howell Hollow area. The assistance of Messrs. T. B. Root, H. A. Sellin, and R. W. Gilson, all members of the Illinois State Geological Survey staff, is gratefully acknowledged in connection with the field investigations incident to this report. Mr. W. W. Rubey, of the U. S. Geological Survey, kindly furnished many data and offered valuable suggestions and criticisms of the manuscript.

SUMMARY

Flint clays occur near Belleview in northern Calhoun County and near Hardin in central Calhoun County (Fig. 1), apparently occupying depressions, probably ancient sink holes, in the Burlington limestone. The two exposures observed exhibit two kinds of flint clay, an upper buff clay and a lower dark gray clay. According to results of tests, the lower dark clay is highly

refractory and comparable to the best Missouri smooth flint clays, whereas the upper buff clays are somewhat less refractory. The outcrops are not of great importance in themselves but establish the existence of flint clay in Illinois and suggest that prospecting may discover additional deposits in

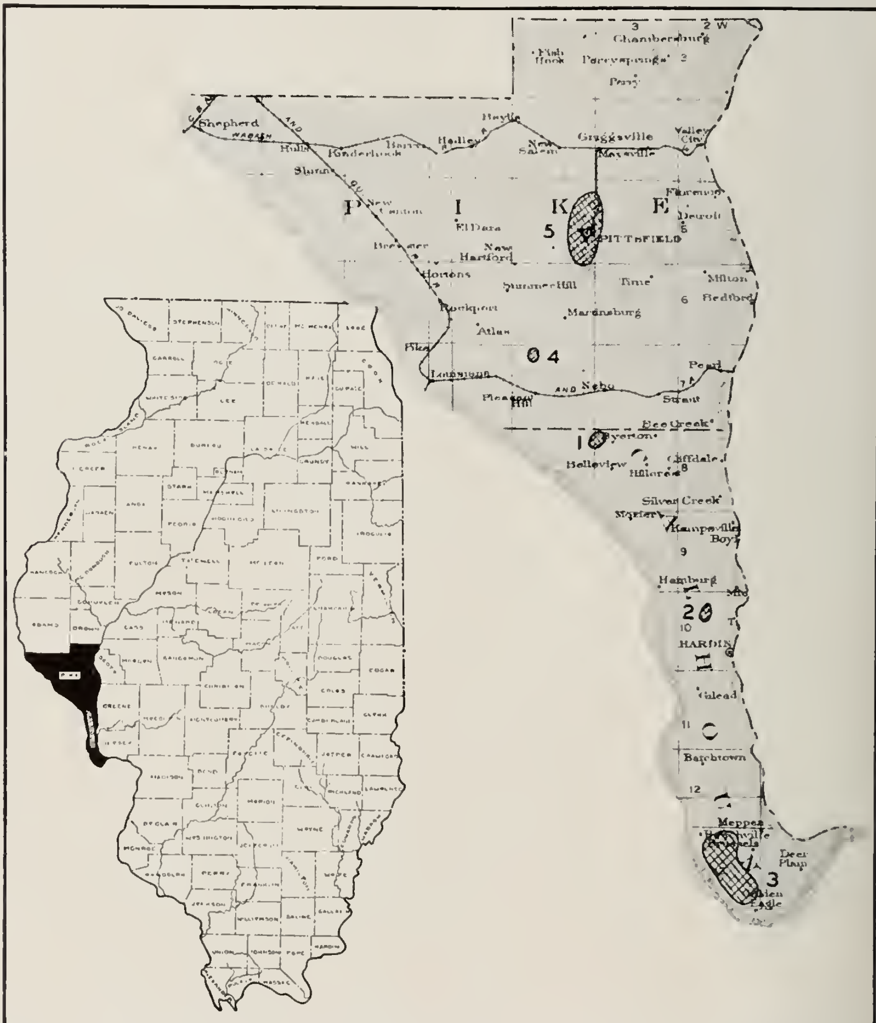

Fig. 1. Maps showing relation of Calhoun and Pike counties to the rest of Illinois and the locations of the various areas discussed in the report: 1, Howell Hollow; 2, DeGerlia Hollow; 3, Southern Calhoun County; 4, Sixmile Creek; 5, Pittsfield.

the vicinity of the known exposures and possibly in adjoining areas. High grade fireclays are associated with the flint clays and appear to be extensive in certain areas. No diaspore clays were observed.

A variety of clays, many of them of about the same quality as those in Calhoun County, occur also in Pike County. In southern and western Pike County there may be deposits of flint clay. In the vicinity of Pittsfield, there are deposits of good quality refractory clay which have been worked to a limited extent in times past. Clay of similar quality has been discovered near Pleasant Hill.

In general the clay resources of Calhoun and Pike counties have been barely touched and exploration will probably reveal numerous additional

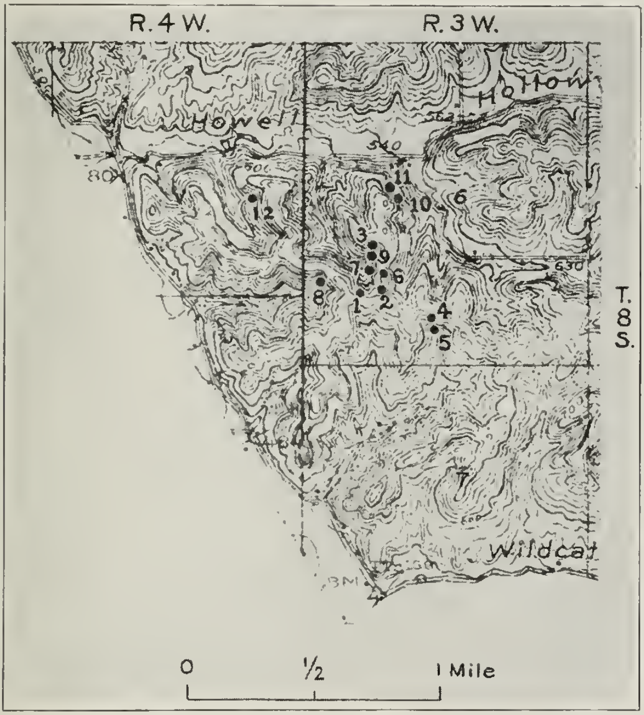

FIG. 2. Topographic map of the Howell Hollow area, indicating the topographic position of the various points shown in figure 3, page 12. (Part of Nebo quadrangle map.)

deposits of high grade clays. The completion of the deep waterway from Chicago to the Gulf of Mexico should encourage development of some of the deposits along Illinois River, which are now not of great commercial value because of the lack of transportation.

AREAS DISCUSSED

The report describes the following five areas (fig. 1): (1) the Howell Hollow area near Belleview in Calhoun County, (2) the DeGerlia Hollow area near Hardin in Calhoun County, (3) the Southern Calhoun County area at the extreme southern tip of Calhoun County, (4) the Pittsfield area in Pike County, and (5) the Sixmile Creek area near Pleasant Hill in Pike County.

HOWELL HOLLOW AREA

Location and Occurrence

The Howell Hollow area lies south of the valley of that name in sec. 1, T. 8 S., R. 4 W., and sec. 6, T. 8 S., R. 3 W., about two miles north of Belleview, four miles southwest of Nebo, and about five miles southeast of Pleasant Hill. It is a part of the uplands bordering the Mississippi River flat and consists of narrow sinuous ridges between steep sided, narrow valleys (fig. 2, p. 9).

Geology

The bedrock of the Howell Hollow area belongs to the Mississippian and Pennsylvanian systems, as shown below:

Bedrock formations exposed in the Howell Hollow area

	Thickness *Feet*
Pennsylvanian system	
Pottsville formation	
Cheltenham (?) member	
Clay, gray, white, and buff	0-15
Mississippian system	
Burlington and Fern Glen formations	
Limestone, coarsely crystalline, cherty, white	60+
Chouteau formation	
Limestone, buff, dolomitic	10-20
Hannibal formation	
Shale, greenish, hard, well bedded	30+

Of the Mississippian formations the Burlington outcrops most extensively and with the Chouteau forms the backbone of the ridges and hills of the region. The Hannibal shale appears beneath the Burlington limestone in a few places, but in general it is not widely exposed.

Above the Burlington limestone lie the most important clay strata of the region. A study of fossil plants from these clays indicate that they are almost certainly of Pennsylvanian age, probably a part of the Pottsville formation.[1] They are therefore tentatively correlated with the Cheltenham clays of the Pennsylvanian system.

The contact of the limestone with the overlying clays could be studied only in Guthrie's old open pit (fig. 3) where the clay fills hollows between

[1] White, David, personal communication to W. W. Rubey.

projecting ridges and knobs of the limestone. Although the contact may not be precisely of this character everywhere, it is believed to be generally irregular.

Normally the clays are overlain by a thin layer of brown and white chert gravel which is probably Lafayette (Pliocene) in age. A deposit of Pleistocene loess or wind-blown clayey silt covers the tops and flanks of the ridges to a depth of 25 to 30 feet and generally obscures the underlying clays and rock.

Clay Resources

Hannibal Shale

OCCURRENCE AND DESCRIPTION

The Hannibal shale outcrops at intervals along the south wall of Howell Hollow, especially in the N. ½ sec. 6, T. 8 S., R. 3 W. It is a greenish, gritty, well bedded shale, which weathers to a greenish, plastic clay.

CERAMIC PROPERTIES

Results of ceramic analyses on two samples of Hannibal shale are given below:

Table 1.—*Results of tests of Hannibal shale*

Sample A

NW. corner, SW. ¼ NE. ¼ sec. 6, T. 8 S., R. 3 W.

Shale, greenish-yellow, very hard; when mixed with water it shows a moderate plasticity; sticky when plastic.

Drying shrinkage . . . . *per cent* 5.92

Burning test:

Cone	Porosity *Per cent*	Shrinkage *Per cent*	Color
03	30.2	3.85	light red
3	4.5	19.0	gray-green

Summary

Suitable for making common brick and tile, and probably for light weight, burned clay aggregate.

Sample B

SW. ¼ SW. ¼ NW. ¼ sec. 6, T. 8 S., R. 3 W.

Shale, greenish, does not develop plasticity.

Drying shrinkage . . . . *per cent* 7.59

Burning test:

Cone	Porosity *Per cent*	Shrinkage *Per cent*	Color
03	19.6	9.5	good red
3	3.9	17.4	light red

Summary

Nonrefractory clay, suitable for brick and tile, and probably for light weight, burned clay aggregate.

These analyses show that the Hannibal shale is suitable for the manufacture of brick and tile, and probably for light weight, burned clay aggregate. Other higher grade ceramic products can probably be made from the shale if some of the fireclay of the Howell Hollow area is mixed with it.

Possibilities of Development

The total thickness of the Hannibal shale in the area is roughly 75 feet, but only about 40 feet of the shale is above the level of the valley flat. A considerable amount of the shale could be obtained by working along the outcrop but if large scale production were undertaken mining would be eventually necessary. The limestone overlying the shale is generally solid and unbroken and would therefore make a good roof if the shale were mined.

Cheltenham Clays

Occurrence and Description

Clays have been discovered in pits or borings at a number of points (fig. 3 and Table 2) on the divides in the Howell Hollow area and are described as red, blue-gray, gray, and white at different places. Although the available data are from diverse sources, it is reasonably certain that there

Fig. 3. Plat showing locations of prospect pits, borings, etc., in the Howell Hollow area. The three-figure numbers give the elevations of the top of the light colored clay; the vertical numbers are for reference to figure 2 and the text. Locations on this map were made by planetable survey.

TABLE 2.—*Records of material penetrated by test-borings and pits in Howell Hollow area*

	Thickness *Feet*
Boring No. 1	
Dirt	27
Gravel	1
Clay, red	2
Clay, white	7+
Boring No. 2	
Dirt	30
Gravel	1
Clay, red	2
Clay, white and blue	9
Boring No. 3	
Soil, gravel, and red clay	30
Clay, white	—
Shaft	
Dirt	27
Gravel	⅔
Clay, red	2
Clay, white	3
Clay, hard, blue and yellow, standing side by side	6
Clay, white	4
Limestone	—
Boring No. 4	
Dirt, gravel, and red clay	28
Clay, white	14+

	Thickness *Feet*
Guthrie's Drift Mine	
Clay, gray	6
Johnson Prospect	
Clay, gray	5
North Johnson Prospect	
Clay, thickness not known.	
Guthrie's South Pit	
Loess	8
Gravel, chert	0-2
Clay, gray	8
Harlow 40 Prospect	
Clay, gray	5
Marqua's Mine	
Loess	6
Gravel, chert and limestone	0-4
Clay, gray	10
Limestone	—
Old Open Pit	
Loess	10+
Gravel, chert	0-6
Clay, gray and white; an irregular thickness of clay lying between ridges of limestone	3-10

are rarely more than three distinct beds of clay. It is known further that a light colored gray, buff, or white clay as much as 14 feet thick (boring No. 4; figs. 2 and 3 and Table 2) constitutes the main body of the deposit and this clay is tentatively correlated with the Cheltenham member of the Pottsville formation. It is normally overlain by about 2 feet of red clay whose age is uncertain and may be Pennsylvanian or post-Pennsylvanian. At some places, the light colored clay is all the same, but at others as in a shaft dug on the top of one of the ridges (No. 6, figs. 2 and 3, Table 2), a bed of hard, blue and yellow flint clay occurs between two white clays.

It seems reasonably certain that the major portion of the ridges in the Howell Hollow tract are capped by the light colored clay overlain by the red clay, over which there is a thin stratum of gravel and then loess. The extent of the flint clay included in the light colored clay is much less certain. In the record of materials penetrated in the shaft it is described as "blue and yellow standing side by side", but those who dug the shaft report that the yellow flint clay overlay blue clay, both beds being variable in thickness and probably lenticular. The flint clay deposits of Missouri, which seem to be of about the same occurrence and character as those of Illinois, are known to be deposits in ancient sinks and are therefore limited in extent. Although there are no data to show definitely that the flint clay in the Howell Hollow area is in an ancient sink, there is reason to believe that it is, in which case it may not be of sufficient extent to be commercially important. However, the known exposure does indicate the presence of flint clay in the area and encourages further search for this valuable clay.

CERAMIC PROPERTIES

The uppermost red clay is of variable character. At some places it contains chert fragments and at others it is relatively free from extraneous material. It is ordinarily plastic and sticky. It has never been tested to determine its value for ceramic purposes, including light weight aggregate, but it is probable that the non-pebbly material might be used in foundries as a clay bond for molding sand or be mixed with other clays either to give them plasticity or to lend a red color to the finished product.

Samples of the light colored, gray, buff or white clay, taken from various pits and openings in the area have been tested and are reported upon in Table 3.

Table 3.—*Results of tests on clay from localities in Howell Hollow area*
(See Figs. 2 and 3 and Table 2)

Sample C

Harlow 40 Prospect

Clay, buff-colored; molds well when plastic although slightly sticky.

Modulus of rupture .... *lbs. per sq. in.* 254

Screen test:

Mesh	Residue *Per Cent*
80	4.4
100	2.25

Drying shrinkage .... *per cent* 7.12

Burning test:

Cone	Porosity *Per Cent*	Shrinkage *Per cent*	Color
3	23.0	8.2	cream
6	17.5	8.3	cream
10	13.0	24.8	cream

Fusion (Deformation) test: P. C. E., Cone 26 (approximately 3002° F.)

Summary

A refractory clay, suitable for fire brick, face brick, stoneware, terra cotta, sanitary ware, and for stove, ladle, and flue linings.

Sample D

North Johnson Prospect

Clay, dull, straw-colored; molds well when plastic.

Modulus of rupture..*lbs. per sq. in.* 217

Screen test:

Mesh	Residue *Per Cent*
80	3.0
100	0.8

Burning test:

Cone	Porosity *Per cent*	Shrinkage *Per cent*	Color
3	16	20.3	dark cream
6	8	23.0	cream
10	1.4	30.5	gray white

Fusion (Deformation) test: P. C. E., Cone 29 (approximately 3310° F.)

Remarks: Seems rather slow to oxidize.

Summary

A refractory clay, suitable for fire brick, face brick, stoneware, terra cotta, sanitary ware, and for stove, ladle, and flue linings.

Sample E

Johnson Prospect

Clay, tan-colored, plastic, very sticky.

Modulus of rupture.................................*lbs. per sq. in.* 465

Screen test:

Mesh	Residue *Per Cent*
80	5.75
100	1.47

Burning test:

Cone	Porosity *Per cent*	Shrinkage *Per cent*	Color
3	6.8	18.5	gray
6	2.87	20.0	gray
10	....	49.9	buff

Fusion (Deformation) test: P. C. E., Cone 23 (approximately 2894° F.)

Remarks: Clay seems to be rather slow to oxidize.

Summary

Suitable for the manufacture of brick and tile.

Sample F

Old Open Pit

Clay, light buff, very plastic, molds readily.

Modulus of rupture..*lbs. per sq. in.* 348

Screen test:

Mesh	Residue *Per Cent*
80	3.45
100	0.97

Drying shrinkage..*per cent* 7.15

Burning test:

Cone	Porosity *Per cent*	Shrinkage *Per cent*	Color
3	4	20.7	gray white
6	0	23.5	gray white
10	1.7	29.6	gray white

Fusion (Deformation) test: P. C. E., Cone 26-27 (approximately 3002°-3038° F.)

Summary

A refractory clay, suitable for face brick, stoneware, sanitary ware, terra cotta, fire brick, crucibles, and for stove, ladle, and flue linings.

Sample G

Old Open Pit

Clay, light, buff-colored, molds well when plastic.

Modulus of rupture......................................*lbs. per sq. in.* 233

Screen test:

Mesh	Residue *Per Cent*
80	3.92
100	1.7

Drying shrinkage..*per cent* 7.15

Burning test:

Cone	Porosity *Per cent*	Shrinkage *Per cent*	Color
3	15.3	24.2	cream
6	12.6	23.4	cream
10	3.5	25.0	gray white

Fusion (Deformation) test: P. C. E., Cone 27-28 (approximately 3038°-3074° F.)

Summary

A refractory clay, suitable for fire brick, face brick, stoneware, terra cotta, sanitary ware, and for stove, ladle, and flue linings.

Sample H

Guthrie's South Pit

Clay, buff-colored, molds well.

Modulus of rupture......................................*lbs. per sq. in.* 242

Screen test:

Mesh	Residue *Per Cent*
80	3.0
100	1.12

Drying shrinkage..*per cent* 7.19

Burning test:

Cone	Porosity *Per cent*	Shrinkage *Per cent*	Color
3	20	14.6	cream
6	15	15.3	cream
10	12.5	26.9	cream

Fusion (Deformation) test: P. C. E., Cone 29-30 (approximately 3074°-3110° F.)

SUMMARY

A refractory clay, suitable for fire brick, face brick, stoneware, terra cotta, sanitary ware, and for stove, ladle, and flue linings.

Sample J

Test Shaft—lower 4 feet white clay [a]

Kind of material..No. 2 fireclay
Reaction for carbonates..None
Reaction for pyrites..None
Color..Light gray
Working property..Good; plastic
Conduct when flowing through a die................Fair; tears a little at corners
Drying conduct..................................Good, no warping or cracking
Volume shrinkage..*per cent* 23.7
Linear shrinkage..*per cent* 7.4
Water of plasticity..*per cent* 25.9
Shrinkage water..*per cent* 12.5
Pore water..*per cent* 13.4

Transverse strength tests of unburned clay:
Modulus of rupture with 50 per cent standard sand
Lbs. per sq. in.. 244
Number of Briquettes.. 14
Modulus of rupture without sand
Lbs. per sq. in.. 279
Number of Briquettes.. 15

Fineness test:

Mesh	Residue *Per cent*	Character of Residue
10	Trace	
20	Trace	
48	0.8	Sandy
100	3.3	Sandy
200	7.3	Sandy
Through 200	88.5	

[a] Tests made by Ceramic Engineering Department, University of Illinois, for the Illinois State Geological Survey.

Burning test:

Cone	Burning shrinkage		Total Shrinkage Linear *Per cent*	Porosity *Per cent*	Color	Hardness
	Linear *Per cent*	Volume *Per cent*				
2	5.2	14.8	12.6	19.9	light buff	almost steel hard
4	5.9	16.6	13.3	17.2	light buff	steel hard
6	5.9	16.6	13.3	17.6	light buff	steel hard
8	6.6	18.5	14.0	16.2	light buff	steel hard
10	7.7	21.3	15.0	7.3	light gray	steel hard
12	8.4	23.1	15.8	7.8	light gray	steel hard
13	9.0	24.6	16.4	4.4	light gray	steel hard

Oxidation conduct..Easily oxidized
Soluble salts..Vanadium (?)
Soluble sulfates ....None
Fusion (Deformation) Test: P. C. E., Cone 30 (approximately 3002° F.)
Warpage ....None
Suggested uses: As a refractory bond clay and in the manufacture of conduit, flue lining, stoneware, terra cotta, face brick, etc.
Remarks: Best burning range, cones 4 to 8 inclusive, for color.

Sample K

Test Shaft—upper white clay [a]

Kind of material..No. 2 fireclay
Reaction for carbonates..Small amount
Reaction for pyrites..None
Color..Light buff
Working property..Good; plasticity excellent
Conduct when flowing through a die..Satisfactory
Drying conduct....................Trace of scum; no warping or cracking
  Volume shrinkage..*per cent* 29.7
  Linear shrinkage..*per cent* 9.1
Water of plasticity..*per cent* 28.0
  Shrinkage water..*per cent* 15.4
  Pore water..*per cent* 12.6
Transverse strength tests of unburned clay:
  Modulus of rupture with 50 per cent standard sand
    Lbs. per sq. in.. 262
    Number of Briquettes.. 13
  Modulus of rupture without sand
    Lbs. per sq. in.. 483
    Number of Briquettes.. 13

a Tests made by Ceramic Engineering Department, University of Illinois, for the Illinois State Geological Survey.

Fineness test:

Mesh	Residue *Per cent*	Character of residue
10	0.1	Pebbles
20	Trace	Pebbles
48	0.1	Sandy
200	3.5	Micaceous, sandy
Through 200	96.1	

Burning test:

Cone	Burning shrinkage		Total Shrinkage Linear *Per cent*	Porosity *Per cent*	Color	Hardness
	Linear *Per cent*	Volume *Per cent*				
2	5.7	16.1	14.8	13.0	cream	almost steel hard
4	6.4	18.1	15.5	10.1	dark cream	steel hard
6	6.4	18.0	15.5	11.1	dark cream	steel hard
8				8.1	dark cream	steel hard
10	7.6	21.0	16.7	4.4	gray	steel hard
12	7.5	20.9	16.6	3.0	gray	steel hard (blistered)
13	4.6	13.2	13.7	13.5	gray	steel hard

Oxidation conduct..Easily oxidized
Soluble sulfates..Trace
Fusion (Deformation) Test: P.C.E., Cone 28 (approximately 2939° F.)
Warpage ....Slight
Suggested uses: Light colored brick, terra cotta, stoneware, probably flue lining and conduits.
Remarks: Best burning range cones 4-8 inclusive. Color quite uniform. Overburned at cone 12.

Sample L

Test Shaft—lower blue-gray flint clay [a]

Kind of material..Flint fireclay
Reaction for carbonates..None
Reaction for pyrites..None
Color ....Gray
Hardness ....Hard
Working property.................................... Poor; very little plasticity
Conduct when flowing through a die..Poor
Drying conduct ....Good
Volume shrinkage..*per cent* 8.9
Linear shrinkage..*per cent* 2.9
Water of plasticity..*per cent* 18.7
Shrinkage water..*per cent* 4.8
Pore water..*per cent* 13.9

[a] Tests made by Ceramic Engineering Department, University of Illinois, for the Illinois State Geological Survey.

Transverse strength tests of unburned clay:

Modulus of rupture with 50 per cent standard sand

Lbs. per sq. in.. 107

Number of Briquettes.. 13

Fineness test: Impossible to slake down for screen analysis.

Burning test:

Cone	Burning shrinkage		Total Shrinkage Linear *Per cent*	Porosity *Per cent*	Color	Hardness
	Linear *Per cent*	Volume *Per cent*				
2	7.6	21.2	10.5	24.5	white	soft (all bars have green scum)
4	9.0	24.6	11.9	21.1	light cream	medium
6	9.7	26.3	12.6	18.4	light cream	almost steel hard
8	10.2	27.6	13.1	16.2	light cream	steel hard
10	12.2	32.3	15.1	14.1	light cream	steel hard
12	11.7	31.2	14.6	13.6	light gray	steel hard
13	12.4	32.8	15.3	12.3	light gray	steel hard

Oxidation conduct.. Easily oxidized

Soluble salts..Vanadium

Soluble sulfates...None

Fusion (Deformation) Test: P. C. E., Cones 33-34 (approximately 3173°-3200° F.)

Warpage ....None

Suggested uses: A very refractory clay, equal in refractoriness to the best of Missouri smooth flints. The firing shrinkage is somewhat excessive but the clay should be valuable in the manufacture of No. 1 refractories. Has sufficient strength to be used for dry press, 100% flint clay brick.

Sample M

Test Shaft, upper yellow flint clay [a]

Kind of material....................................Low grade flint fireclay

Reaction for carbonates.....................................None

Reaction for pyrites..None

Color ....Yellow

Working Property.............................Poor; very little plasticity

Drying conduct ....Good

Volume shrinkage..................................*per cent* 12.8

Linear shrinkage..................................*per cent* 4.1

Water of plasticity...............................*per cent* 25.0

Shrinkage water...................................*per cent* 7.4

Pore water..*per cent* 17.6

Conduct when flowing through a die..........................Poor

Transverse strength tests of unburned clay:

Modulus of rupture with 50 per cent standard sand

Lbs. per sq. in.. 119

Number of Briquettes.. 13

a Test made by Ceramic Engineering Department, University of Illinois, for the Illinois State Geological Survey.

Fineness test: Impossible to slake down for screen analysis.

Burning test:

Cone	Burning shrinkage		Total Shrinkage Linear *Per cent*	Porosity *Per cent*	Color	Hardness
	Linear *Per cent*	Volume *Per cent*				
2	11.5	30.6	15.6	19.8	salmon pink	
4	12.5	33.0	16.6	16.3	salmon pink	steel hard
6	13.0	34.2	17.1	15.5	salmon pink	steel hard
8	13.9	36.1	18.0	14.6	pinkish tan	steel hard
10	15.0	38.5	19.1	11.3	rusty brown	steel hard
12	15.2	39.1	19.3	10.0	darker brown	steel hard
13	10.5	28.3	14.6	9.2	dark brown	steel hard

Oxidation conduct..Easily oxidized
Total soluble salts..Vanadium ?
Soluble sulfates ....None
Fusion (Deformation) test: P.C.E., Cone 28-29 (approximately 2939°-2984° F.)
Warpage ....None
Suggested uses: Would be useful with plastic fireclay of excessive shrinkage in making No. 2 refractories. Not sufficiently plastic to be used alone.
Remarks: Peculiar because of dark red color and apparent refractoriness throughout wide temperature range

The foregoing analyses show that the clays of the Howell Hollow area are generally refractory and are suited to the manufacture of a wide variety of products. Because they are refractory, the clays are probably not well adapted to making light weight, burned clay aggregate by processes now used commercially. The samples from the Harlow and Johnson prospects (Table 3—C, D, and E) were taken relatively near the outcrop of the clay beds and may not be as representative of the deposits nor as reliable in showing the true character of the clay as those taken from the mines or the shaft. The deposit in the Johnson prospect (Table 3, Sample E) appears to have been mixed with loess, or altered by the infiltration of soluble salts from the overlying loess.

The flint clay appears to be of two grades (Table 3, Samples L and M). The lower clay is of very high quality and is equal to the best Missouri flint clays. It is highly refractory and burns white or gray. The "upper yellow" flint clay is also of good quality but is somewhat less refractory than the gray clay and burns to a pink or brown color.

CHEMICAL COMPOSITION

Available chemical analyses of the Howell Hollow clays indicate that they are relatively high in alumina and low in impurities. (Table 4). The gray flint clay closely approaches true kaolin in chemical composition.

Table 4.—*Chemical analyses of clay*
(See fig. 3)

Chemical constituents	"Old Open Pit" Upper, soft, white, plastic clay *per cent*	"Old Open Pit" Lower, grayish-white, hard clay *per cent*	Shaft Lower, gray, flint clay [a] *per cent*
Silica	52.00	57.24	45.17
Alumina	33.39	30.74	38.78
Iron oxide	2.21	1.74	1.78
Magnesium oxide	0.84	0.30	0.07
Calcium oxide...	Trace	Trace	0.71
Sulfur trioxide...	.....	......	0.33
Loss on ignition.	11.52	10.03	13.16

[a] Analysis made by Chemistry Department, University of Illinois, for the Illinois State Geological Survey.

POSSIBILITIES OF DEVELOPMENT

The clays, except the flint clay, are plastic when wet, so that from time to time they may have flowed slightly. If this has occurred, the deposits should be somewhat thinner and lower in the margins of the rides than in the crests. In other words, as a clay bed is followed into the ridge from the outcrop it will probably be found to "rise in the hill" and possibly to thicken. Limited field observations confirm this suggestion.

The light colored clays will probably be found to form a relatively continuous sheet or stratum on divides where the clays are present. Some lateral variations may occur but it is believed that the general character of the clays will be relatively constant.

The flint clays are probably more or less lenticular, and it is recommended therefore that test-borings spaced 100 feet apart be made to ascertain the extent of the deposit before development of these clays is attempted. If borings spaced at this distance do not distinctly outline the flint clay, additional borings at closer intervals should be made. The borings should be made with an auger or other instrument that will yield uncontaminated samples, which should be carefully examined to determine the thickness and character of the flint clays and saved for testing.

Prospecting for new deposits in the vicinity of Howell Hollow is likely to be most fruitful on the hills having an elevation of more than 725 feet and outcrops of clay are most likely to be found on the flanks of such hills between elevations of 665 and 700 feet. Test-boring, followed by the digging of test pits, is recommended for exploration of deposits.

Loess

The loess in the Howell Hollow area is not known to have been tested to determine its ceramic properties. However, loess from other parts of the State has been tested and that which is not calcareous is useful in making common brick and tile. The upper, leached portion of the loess in the Howell Hollow area presumably could be used for the same purposes. Tests may show that it is adapted to making light weight, burned clay aggregate, and other special uses may probably be developed for it by mixing with it other higher grade clays.

Clays in Region Adjoining the Howell Hollow Area

Outside the Howell Hollow area, clay outcrops are reported at several places but it is not known whether or not these reported exposures represent deposits large enough to be of commercial importance. Detailed prospecting in northern Calhoun and southern Pike counties may reveal additional deposits of clays generally similar to the Howell Hollow deposits.

DeGERLIA HOLLOW AREA

Location and Occurrence

Flint clay crops out in two small valleys tributary to DeGerlia Hollow in the SW. ¼ SE. ¼ SE. ¼ sec. 8, T. 10 S., R. 2 W., on the Hazelwonder farm about 3½ miles northwest of Hardin, Calhoun County (fig. 4). The deposit lies well down the east slope of the sinuous, north-south ridge that

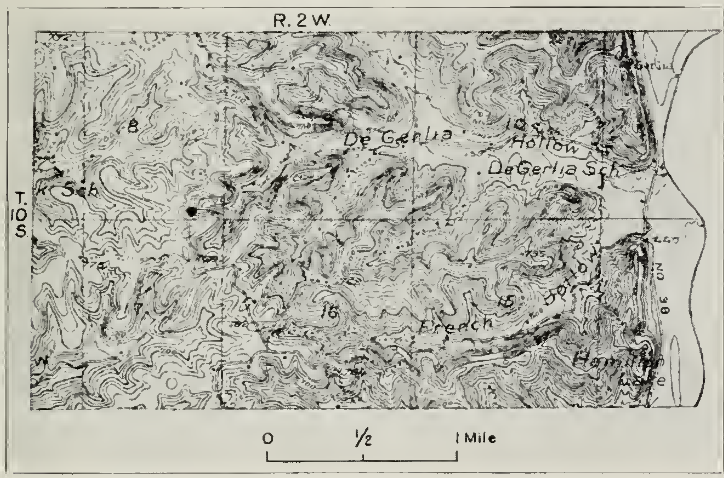

Fig. 4. Topographic map of DeGerlia Hollow area showing location of outcrop of flint clay. (Part of Hardin quadrangle map.)

forms the watershed between Illinois and Mississippi rivers. The elevation of the uppermost flint clay of the deposit is approximately 720 feet,[2] which is only slightly higher than the fireclay and flint clay in the Howell Hollow area.

[2] Rubey, W. W., personal communication.

Geology

The mode of occurrence of the clay is not exactly known, but it probably rests on or against the Burlington limestone which forms the core of the ridge, and it may occupy an old sink hole. The observed outcrops were small but the following sequence of strata was determined:

Composite geologic section in tributaries of DeGerlia Hollow

	Thickness Feet	Thickness Inches
12. Covered, mostly loess	..	..
11. Clay, white, stained brown and yellow by iron oxide; contains fragments of chert	1	0
10. Covered	3	2
9. Flint clay, light gray, weathers tan	1	0
8. Covered	2	6
7. Flint clay, light gray, weathers tan	1	0
6. Covered	2	3
5. Flint clay, medium to dark gray	0	6
4. Covered	1	6
3. Flint clay, medium to dark gray (Table 5, Sample N)	2	9
2. Clay, soft, white, plastic; contains small calcium carbonate pellets and is locally stained slightly yellow by iron oxide (Table 5, Sample O)	1	6
1. Covered	1	6

Clay Resources

Flint Clay

occurrence and description

If the interval including and lying between beds 3 and 9 in the above geologic section is composed entirely of clay, as suggested by the frequent outcrops of the clay between the uppermost and lowermost exposures, there is 11½ feet of flint clay in the DeGerlia Hollow area. There appear to be two grades of flint clay in this area, as in the Howell Hollow area. Beds 3 and 5 in the DeGerlia Hollow geologic section are dark gray and are possibly the equivalent of the bottom flint clay in the Howell Hollow test shaft, whereas the upper light gray or tan clay, beds 7 and 9 in the DeGerlia Hollow section, seems equivalent to the upper flint clay in the Howell Hollow test shaft. If the covered interval 4 in the DeGerlia Hollow section is dark gray flint clay, this variety of clay has a total thickness of 4 feet 9 inches; similarly, if the covered interval 8 is light gray clay, the light clay is 4 feet 6 inches thick. The covered interval 6, comprising 2 feet 3 inches of the section, may be either or both light or dark colored flint clay.

Fireclay

OCCURRENCE AND DESCRIPTION

Lying below the flint clay is a deposit of soft, white plastic fireclay represented by bed 2. Above the flint clay is another white clay, bed 11, containing fragments of chert. Although only 1½ feet of the lower clay is exposed, a greater thickness of this clay may be present. The upper cherty clay also may be thicker than at the outcrop and possibly largely free from chert.

CERAMIC PROPERTIES OF FLINT CLAY AND FIRECLAY

According to the results of tests on sample N taken from bed 3, this clay is a high grade flint clay equal in refractoriness to the best Missouri smooth flint clays. (Table 5, Sample N.)

Tests on sample O taken from bed 2 show that, despite its content of small pellets of calcium carbonate, it is a good grade fireclay (Table 5, Sample O).

Table 5.—*Results of tests on clay from the DeGerlia Hollow*

Sample N

Outcrop in the SW. ¼ SE. ¼ SE. ¼ sec. 8, T. 10 S., R. 2 W.[a]

Kind of material		Flint fireclay
Reaction for carbonates		None
Reaction for pyrites		None
Color		Silver gray
Hardness		Very hard for raw clay. Can be scratched with fingernail with some difficulty.
Working property		Works very well and easily after the first few minutes of wedging.
Drying conduct		Can be dried very quickly without warping or cracking.
Volume shrinkage	*per cent*	10.1
Linear shrinkage	*per cent*	2.5
Water of plasticity	*per cent*	22.0
Shrinkage water	*per cent*	5.5
Pore water	*per cent*	16.5
Transverse strength tests of unburned clay		
Modulus of rupture without sand		
Lbs. per sq. in.		78
Number of Briquettes		15
Fineness test:		
Impossible to slake all the clay to obtain screen analysis. The clay is very fine grained; all that slakes passes the 200-mesh sieve.		
Slaking test	*minutes*	6

a Tests made by Ceramic Engineering Department, University of Illinois, for the Illinois State Geological Survey.

Burning test:

Cone	Burning shrinkage		Porosity	Color	Hardness
	Linear *Per cent*	Volume *Per cent*	*Per cent*		
01	6.1	12.1	31.4	white	not steel hard
2	6.6	18.6	30.4	cream	not steel hard
3	....	....	....	cream	not steel hard
4	8.5	23.5	26.1	cream	steel hard
6	9.3	25.3	23.9	cream	steel hard
8	9.7	26.4	22.1	cream	steel hard
10	11.0	29.5	18.8	cream	steel hard
12	11.8	31.3	16.8	gray	steel hard
14	13.0	34.2	14.2	gray	steel hard
16	13.6	35.5	12.3	gray	steel hard

Soluble sulfates ....None
Warpage ....None
Fusion (Deformation) test: P. C. E., Cone 33-34 (approximately 3173°-3200°F.)
Suggested uses: The clay should be a valuable raw material for use in the manufacture of high-grade flint fireclay refractories. In refractoriness the clay is equal to the best of the Missouri smooth flint clays. The firing shrinkage of the clay is somewhat excessive and this would probably necessitate the use of a large amount of calcined clay.

Sample O

Outcrop in the SW. ¼ SE. ¼ SE. ¼ sec. 8, T. 10 S., R. 2 W.[a]

Kind of material..No. 2 fireclay
Reaction for carbonates..Present
Color ....Almost white
Working property..Fair; sticky
Drying conduct ....Good
  Volume shrinkage ....*per cent* 32.3
  Linear shrinkage ....*per cent* 9.8
Water of plasticity..*per cent* 33.5
  Shrinkage water ....*per cent* 17.8
  Pore water ....*per cent* 15.7
Transverse strength tests of unburned clay
  Modulus of rupture with 50 percent standard sand
    Lbs. per sq. in.. 406
    Number of Briquettes.. 10
  Modulus of rupture without sand
    Lbs. per sq. in.. 694
    Number of Briquettes.. 10

[a] Test made by Ceramic Engineering Department, University of Illinois, for the Illinois State Geological Survey.

Fineness test:

Mesh	Residue *per cent*	Character of residue
10	0.5	Small lime pebbles
20	0.6	Small lime pebbles
48	0.8	Small lime pebbles
100	0.5	Sand and lime pebbles
200	0.5	Sand and lime pebbles
Through 200	97.1	

Burning test:

Cone	Burning shrinkage		Total Shrinkage Linear *Per cent*	Porosity *Per cent*	Color	Hardness
	Linear *Per cent*	Volume *Per cent*				
2	10.0	27.1	19.8	8.8	light buff	
4	11.1	29.7	20.9	3.7	light buff	
6	11.7	31.1	21.7	0.6	buff	
10	12.3	31.8	21.8	0.0	gray	
12	10.9	29.3	20.7	0.5	gray	(fused lime spots)
13	9.3	25.4	19.1	3.8	gray	(fused lime spots)

Oxidation conduct..Easily oxidized
Soluble sulfates ....None
Fusion (Deformation) test: P.C.E., Cone 29 (approximately 2984° F.)
Warpage...Warps a little; high shrinkage
Suggested uses: Aside from disadvantage of high shrinkage the clay should be an excellent stoneware material, refractory bond clay, terra cotta and face brick clay. Firing range for zero absorption and constant shrinkage, cones 6 to 10 or 12, inclusive. Between cones 8 and 10 the color changes to gray.

POSSIBILITIES OF DEVELOPMENT

The occurrence of flint clay in DeGerlia Hollow may signify potential resources of this clay in the area although the outcrop itself is not necessarily of great economic importance. A careful search of the neighboring valleys revealed no other outcrops of flint clay but white plastic clays similar to those associated with the flint clay were noted at two places in the NW. ¼ sec. 17, T. 10 N., R. 2 W., at elevations of 700 and 720 feet.[3] Therefore the flint clay too may not be limited to the small gully in which it crops out, and additional deposits in the vicinity may be revealed by a general plan of prospecting similar to that outlined in connection with the Howell Hollow area (p. 22). As the clay is believed to occur in sinks, the extent of any one deposit can be roughly ascertained if the limestone rim of the sink can be outlined. It is recommended that the prospecting be con-

[3] Rubey, W. W., personal communication.

centrated along the upper slopes of ridges having an elevation of more than 725 feet, as the normal position of the clay is at an elevation of about 700 to 720 feet and it will probably not be found in place below an elevation of 665 feet. Inasmuch as the DeGerlia Hollow deposit, in part at least, has a thick overburden, the extent of the deposit and the thicknesses of the clays and overburden should be definitely determined before development is begun.

ORIGIN OF CALHOUN COUNTY FLINT CLAYS

An adequate understanding of the origin of any clay or other mineral deposit is essential for intelligent commercial development. Data bearing on the origin of the Calhoun County flint clays are so meager and fragmentary because of the limited exposures that any conclusions must be derived by inference rather than by direct observation.

The flint clays in Missouri are commonly found in depressions which are interpreted as ancient sink holes, the walls of which are normally lined with more or less sandstone upon which the flint clays rest. Wheeler[4] ascribed the sandstone lining of the sinks and certain structural features of the clay itself to deposition in pre-Pennsylvanian sink holes that had developed in underlying limestone formations, but McQueen[5] has suggested that the clay and underlying sandstone originally were deposited as a horizontal series which later slumped into limestone sinks formed after the deposition of the sandstone and clay. It is further suggested that the sink holes offered excellent avenues for the descent of surface waters which leached and removed the silica and thereby increased the per cent of alumina in the clay.

The Illinois flint clays appear to be a northeastward extension of the Missouri deposits, and so it is reasonable to assume that they possess many characteristics common to the Missouri deposits. They are thought to occur in sink holes, whose age is not definitely established, but which probably developed before the present drainage systems were formed, inasmuch as the narrow ridges upon which the sinks are now found are not the normal place for the development of sink holes. Above the flint clays and associated fireclays, no beds definitely of Pennsylvanian age have been found in Illinois. Instead there is usually a foot or two of chert gravel with a clay matrix, which has evidently been derived mostly from adjacent higher areas and is probably considerably younger than the clay on which it rests.

Diaspore clays or burley flint clays are locally associated with the smooth flint clays in Missouri but are limited to the north central Ozark district of Missouri, except for one occurrence of burley clay in the northern part of Lincoln County, Missouri, immediately west of Calhoun County.[6] So

[4] Wheeler, H. A., Clay Deposits, Missouri Geol. Survey, vol. 11, p. 202, 1896.
[5] 5 McQueen, H. S., Geologic relations of the diaspore and flint clays of Missouri, Bull. Amer. Cer. Soc., vol. 12, No. 10, p. 695, Oct. 1929.
[6] McQueen, H. S., op. cit. p. 696.

far as is known there are no deposits of diaspore or burley clay in Illinois. The only suggestion of high alumina clays in Illinois was observed by Van Pelt[7] in some of the pits in the so-called Cheltenham bed near White Hall, Greene County, where a discontinuous band of calcareous pisolitic nodules is found. These nodules, of which the largest is about 10 inches in diameter, contain small amounts of the mineral diaspore but are without commercial significance. Although the general field evidence does not point to the occurrence of diaspore clay in Illinois, the possibility of its existence should not be overlooked.

SOUTHERN CALHOUN COUNTY AREA[8]

Location and Occurrence

The southern Calhoun County area includes the uplands of that part of Calhoun County lying south of an east-west line through Beechville in sec. 33, T. 13 S., R. 2 W. A large portion of the area is underlain by Pennsylvanian strata, which include thick shale beds and the underclay below the Golden Eagle (No. 2) coal, thought to be the equivalent of the Cheltenham clays of Illinois and Missouri.

Geology

The general sequence of strata found in southern Calhoun County may be described briefly as follows:[9]

Generalized geologic section of Pennsylvanian strata in Southern Calhoun County

	Thickness Feet
Unconformity	
McLeansboro formation	
12. Limestone, gray, weathers brown; dense, massive, fossiliferous; forms a prominent ledge	5+
11. Clay, calcareous, pale buff	15±
10. Limestone, dark gray, dense; massive below, thin bedded above; fossiliferous; somewhat conglomeratic	8±
	28±
Carbondale formation	
9. Clay, calcareous, pale greenish-gray with thin carbonaceous zones at top and bottom; contains irregular masses of white, calcareous powder	4 to 12±

[7] Van Pelt, J. R., personal communication.
[8] The data on this area were obtained partly in cooperation with W. W. Rubey during the sampling of the non-metallic mineral deposits of the Brussels quadrangle and partly from the following bulletins: Parmelee, C. W., and Schroyer, C. R., Further Investigations of Illinois Fire Clays, Illinois State Geol. Survey Bull. 38D, pp. 81 and 82, 1921; and Weller, Stuart, Notes on the Geology of Southern Calhoun County, Illinois State Geol. Survey Bull. 4, pp. 229-233, 1907.
[9] Rubey, W. W., Geology and Mineral resources of the Hardin-Brussels quadrangles, Illinois Geol. Survey, Unpublished manuscript.

	Thickness *Feet*
8. Limestone, light gray, fine grained, massive below, nodular above; somewhat conglomeratic; weathers to an irregular knobby surface and forms a prominent ledge..........	6±
7. Fireclay, pale gray to white, mottled with yellow, brown, red, maroon, and purple and with thin carbonaceous zone at top	3— to 15+
6. Shale and siltstone, noncalcareous, sandy, micaceous, greenish to buff-gray, brown and maroon, platy to massive; grades laterally into very fine grained argillaceous sandstone	50±
5. Black laminated shale or very argillaceous coal; locally pyritic, fossiliferous, and with ferruginous nodules and layers of dense gray limestone less than 1 inch thick....	A few inches to 4—
4. Coal, contains a local parting of clay shale and ferruginous concretions near top..................................	A few inches to 3—
	65 to 90
Pottsville formation	
3. Fireclay, gray to white, locally pyritic; contains concretionary masses of pisolitic or phosphatic limestone near top..	0 to 12+
2. Clay, sandy; dark shale, and argillaceous sandstone; poorly exposed	0 to 12+
1. Sandstone, locally conglomeratic and cross-bedded........	0 to 20+
	0 to 85+ (commonly 10 to 35)

Unconformity

The Pennsylvanian formations are usually best exposed in the valleys on the west side of the major northwest-southeast divide. The coal and its associated clays doubtless underlie a large part of the region and the overlying shales also outcrop over a wide area, being especially common in the heads of the valleys.

Ceramic Properties of Clays

The underclay (bed No. 3, geologic section) below the Golden Eagle coal appears to be a refractory clay of good quality, as fire brick graded as St. Louis No. 1 were formerly made from it. Tests made on two samples, one taken from a pile of clay near the mine of the Golden Eagle plant where it had evidently been dug several years previously but appearing fresh and unweathered (Sample P), and the other obtained from an exposure in a gully in the NE. ¼ SW. ¼ SW. ¼ sec. 34, T. 12 S., R. 2 W., near Beechville (Sample Q), indicate that the clay will probably be satisfactory for making light colored face brick, conduits, refractories and terra cotta, and as a refractory bond clay (Samples P and Q). The clays appear to be too refractory for making light weight, burned clay aggregate by processes now used commercially.

Table 6.—*Results of tests*[a] *on clay from pit of Thomas Brick Company near Golden Eagle, Southern Calhoun County*

Sample P

Underclay of Golden Eagle Coal

Clay, very hard, grayish colored; contains much finely divided pyrite. Upon the addition of a suitable amount of water it develops a good degree of plasticity but is sticky. It slakes very slowly.

Water of plasticity . . . *per cent* 34.4
Shrinkage water . . . *per cent* 25.5
Pore water . . . *per cent* 18.9
Modulus of rupture . . . *lbs. per sq. in.* 165.7
With 50% standard sand—Modulus of rupture . . . *lbs. per sq. in.* 124.6
Slaking test: . . . *hours* 5½

Screen test:

Mesh	Residue *Per cent*	Character of residue
120	.50	Pyrites, sand, clay, and organic material
150	.09	Mica and sand
200	.12	Pyrites, sand, clay, and organic material

Drying shrinkage:
Linear; wet length . . . *per cent* 10.05
Linear; dry length . . . *per cent* 11.6

Burning test:

Cone	Porosity *Per cent*	Burning Shrinkage *Per cent*	Color	Remarks
2	10.0	6.1		
5	5.2	6.0	tan	Small black core
9	7.0	4.3	buff	Black core, fine iron spots
12	5.0	5.0	buff exterior; bluestoned	
13	7.0	2.6		Flashed
15	5.5	2.8	buff; bluestoned	Overburned

Fusion test: Cone ⅓ deformed at cone 26 (approximately 2903°F.). The cone has a vesicular structure.

Summary

This clay has a medium low strength and a medium low bonding strength. The drying shrinkage is medium high. The effect of the small residue of finely divided pyrite becomes evident at the higher temperatures, especially in the fusion test. Washing the clay for some products will correct this. The poor

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[a] Parmalee, C. W., and Schroyer, C. R., Further investigations of Illinois fire clays: Illinois State Geol. Survey, Bull. 38D, p. 81, 1921.

oxidation conduct should be noted. The clay is on the border line between a non-refractory and a refractory material. The test piece has the appearance of having been overfired at cone 15.

Suggested uses: Architectural terra cotta, face brick.

Sample Q

Underclay of Golden Eagle coal from gully in NE. ¼ SW. ¼ SW. ¼ sec. 34, T. 12 S., R. 2 W.

Kind of material .... No. 2 fireclay
Reaction for carbonates .... Small amount present
Color .... Light buff
Working property .... Fair; sticky
Drying conduct .... Good
  Volume shrinkage .... *per cent* 29.4
  Linear shrinkage .... *per cent* 8.9
Water of plasticity .... *per cent* 27.7
  Shrinkage water .... *per cent* 15.4
  Pore water .... *per cent* 12.3
Transverse strength tests of unburned clay
  Modulus of rupture with 50 per cent standard sand
    Lbs. per sq. in. 312
    Number of briquettes 9
  Modulus of rupture without sand
    Lbs. per sq. in. 487

Screen test:

Mesh	Residue *per cent*	Character of residue
10	Trace	Small lime pebbles
20	0.1	Small lime pebbles
48	0.1	Sandy
100	0.3	Sandy
200	1.1	Sandy
Through 200	98.4	

Burning test:

Cone	Burning shrinkage		Total Shrinkage	Porosity	Color	Hardness
	Linear *Per cent*	Volume *Per cent*	Linear *Per cent*	*Per cent*		
2	7.6	21.0	16.5	19.5	cream	steel hard
4	7.9	21.8	16.8	17.4	cream	steel hard
6	8.0	22.0	16.9	16.5	cream	steel hard
8	8.4	23.2	17.3	14.2	slightly darker	steel hard
10	9.1	24.8	18.0	11.4	slightly darker	steel hard
12	10.0	27.0	18.9	5.9	gray	steel hard
13	10.4	28.0	19.3	1.2	rusty	steel hard (fused lime spots)

Oxidation conduct ....Easily oxidized
Total soluble salts..Vanadium
Fusion (Deformation) Test: P. C. E., Cone 30 (Approximately 3002° F).
Warpage ....None
Suggested uses: Light colored face brick, conduit, refractories, refractory bond clay, terra cotta, quarry tile, roofing tile.
Remarks: Good burning range—cones 4-8 inclusive for light color.

The shales (bed No. 6, geologic section) overlying the coal formerly furnished raw material for the manufacture of pressed brick. Of the 35 feet of these shales exposed in the old pit the lower 12 to 15 feet is greenish gray and the upper 20 feet is maroon or mottled maroon and green. Tests on sample R, taken from the 35 feet of outcropping shales, show that it is suited for the manufacture of face brick, paving brick, roofing tile, and probably light weight, burned clay aggregate.

TABLE 6.—*Continued*

Sample R

Maroon shale above Golden Eagle coal

Kind of material..Shale
Reaction for carbonates..Present
Reaction for pyrites..None
Color..Light chocolate brown
Working property..Not very plastic
Conduct when flowing through a die..Satisfactory
Drying conduct ....Small amount of scum. No warping
Volume shrinkage ....*per cent* 20.1
Linear shrinkage ....*per cent* 6.3
Water of plasticity..*per cent* 26.2
Shrinkage water ....*per cent* 10.8
Pore water ....*per cent* 15.4
Transverse strength of unburned clay
Modulus of rupture with 50 per cent standard sand
Lbs. per sq. in... 289
Number of Briquettes.. 12
Burning test:

Cone	Burning shrinkage		Total Shrinkage	Porosity	Color	Hardness
	Linear *Per cent*	Volume *Per cent*	Linear *Per cent*	*Per cent*		
05	8.3	22.8	14.6	12.3	light red	steel hard
03	10.7	28.7	17.0	1.1	reddish brown	steel hard
1	10.6	28.5	16.9	0.8	good dark red	steel hard
2	10.4	28.1	16.7	0.4	good dark red	steel hard
4	8.6	23.6	15.9	0.5	very dark red	steel hard

Oxidation conduct..Oxidizes easily at low temperature
Warpage ....None
Soluble sulfates ....Trace

Suggested uses: The shale burns to a good color and has an excellent firing range—cones 03 to 2 inclusive—and should be valuable for brick manufacture, paving brick, quarry tile and roofing tile.

Sample R

Chemical analysis

	Per cent
Lime (CaO)	1.05
Magnesia (MgO)	2.04
Silica (SiO_2)	58.04
Alumina (Al_2O_3)	24.40
Iron oxide (Fe_2O_3)	6.66
Sulfuric anhydride (SO_3)	0.86
Loss on ignition	7.61
	100.66

Tests made on a sample taken from the lower 4 feet of a 5-foot bed of non-bedded clay (Bed No. 7, geologic section) above the green and maroon shale in the Golden Eagle pit indicate that it is moderately refractory and could be used for light colored brick, terra cotta, quarry tile, and roofing tile. The clay is probably too refractory to be well adapted for making light weight, burned clay aggregate. (Sample S.)

TABLE 6—*Continued*

Sample S

Clay above maroon and green shale

Kind of material		Clay
Reaction for pyrites		None
Color		Cream
Working property		Good
Drying conduct		Satisfactory
Volume shrinkage	*per cent*	27.4
Linear shrinkage	*per cent*	9.3
Water of Plasticity	*per cent*	27.4
Shrinkage water	*per cent*	15.8
Pore water	*per cent*	11.6

Transverse strength tests of unburned clay—Not enough clay to test.

Screen test:

Mesh	Residue *Per cent*	Character of residue
10	0.0	....
20	0.0	....
48	0.1	Sandy
100	Trace	....
200	3.6	Sandy, micaceous
Through 200	96.3	

Burning test:

Cone	Burning shrinkage Linear Per cent	Burning shrinkage Volume Per cent	Total Shrinkage Linear Per cent	Porosity Per cent	Color	Hardness
03	6.4	17.9	15.7	2.0	light tan	steel hard
01	6.4	18.1	15.7	0.6	tan	steel hard
2	6.6	18.4	15.9	0.5	tan	steel hard
4	6.6	18.5	15.9	0.8	grayish tan	steel hard
8	6.2	17.4	15.5	1.7	grayish tan	steel hard
10				Flat		

Oxidation conduct...Easily oxidized
Soluble sulfates...None
Fusion (Deformation) Test: P. C. E., Cone 15 (approximately 2615° F.)
Warpage ....None
Suggested uses: The clay has a long firing range and could be used for light colored brick, terra cotta, quarry tile, and roofing tile. Overburned at cone 8.

Possibilities of Development

The fact that three clays of different degrees of refractoriness and of different character are available in southern Calhoun County, locally all three at one place, makes this region one of particular interest to the clay products manufacturer desiring diversified raw materials and products. Although none of the clay is being utilized at the present time, its economic importance is evident from the fact that the Thomas Brick and Clay Company formerly operated a plant with a capacity of 25,000 to 30,000 bricks per day near the center of sec. 1, T. 14 S., R. 2 W., about 1½ miles southeast of Golden Eagle, and shipped large quantities of No. 1 fire brick to St. Louis. The company mined about 5 feet of the underclay below the Golden Eagle coal and also mined the coal. The clay below the mined portion was not utilized because it contained nodular masses of limestone full of pyrite. The green and yellow-green shale above the coal was used for pressed brick.

Calhoun County is handicapped by the lack of railroads. The Thomas Brick and Clay Company loaded their bricks in railroad cars which were ferried to connections at Peruque, Missouri, or Grafton, Illinois. However, the increasing interest in waterway transportation of bulky materials enhances the potential value of mineral deposits located near navigable streams. In the case of the clays in southern Calhoun County, they or the products made from them could be shipped on Mississippi River which is cutting along its east bank so that deep water and numerous favorable sites for dock loading platforms are available on the west and south sides of the area. Any clay mine or pit should be located so as to take advantage of these natural facilities. Topographic maps[10] will assist in the selection of a plant or pit site.

Open-pit mining, necessitating relatively large scale development, may be feasible at a number of places where it is possible to use the shale overlying the underclay and coal. In smaller operations subsurface mining will probably be more advisable for working the coal and underclay. Commercial development of the underclay of the Golden Eagle coal appears to offer most favorable economic conditions, as the coal can be mined with the clay and would furnish perhaps half the fuel necessary to burn the products.

The underclay of the Golden Eagle coal and its associated shale strata appear to be relatively constant in character and distribution, so that less test drilling is needed to determine their quality and extent than in the case of more variable deposits. However, tests should be made to make sure that no unexpected changes occur in the character and thickness of the clay or shale and to prove the presence of a sizeable body of raw material before operations are begun.

PITTSFIELD AREA

Location and Occurrence

In former years clay for the manufacture of brick and tile and for use with other clays in making pottery has been dug at a number of places in the vicinity of Pittsfield. One of the most extensively worked deposits was in the low bluffs on the south side of Bay Creek in sec. 12, T. 5 S., R. 4 W., about two miles north of Pittsfield. The outcrop is now covered but the following geologic section is reported to have been exposed when clay was being dug:

	Feet	*Inches*
Loess and drift	0—20	
Gravel		0—10
Clay, white	2±	
Clay, gray (Sample T)	12±	

Borings in the immediate vicinity of this exposure show that the clay underlies a tract several acres in extent, and the topography suggests that large areas to the south and to the east may be also underlain by the clay.[11] Other outcrops of clay are reported about two miles south of Pittsfield[12] and about 3½ miles south of Pittsfield.

Two to five feet of white, highly plastic clay, containing angular chert fragments, overlain by six to fourteen feet of stream silt, loess, and drift

[10] Available for 10 cents each at Illinois State Geological Survey, Urbana, Illinois, or at U. S. Geological Survey, Washington, D. C.

[11] Parmelee, C. W., and Schroyer, C. R., Further Investigations of Illinois Fire Clays, Illinois State Geol. Survey Bull. 38D, p. 99, 1921.

[12] Lines, E. H., Pennsylvanian Fire Clays of Illinois, Illinois State Geol. Survey Bull. 30, p. 69, 1917.

is exposed along Honey Creek near the center of the north half of sec. 26, T. 5 S., R. 4 W., on the outskirts of Pittsfield. Sample U was taken from this exposure.

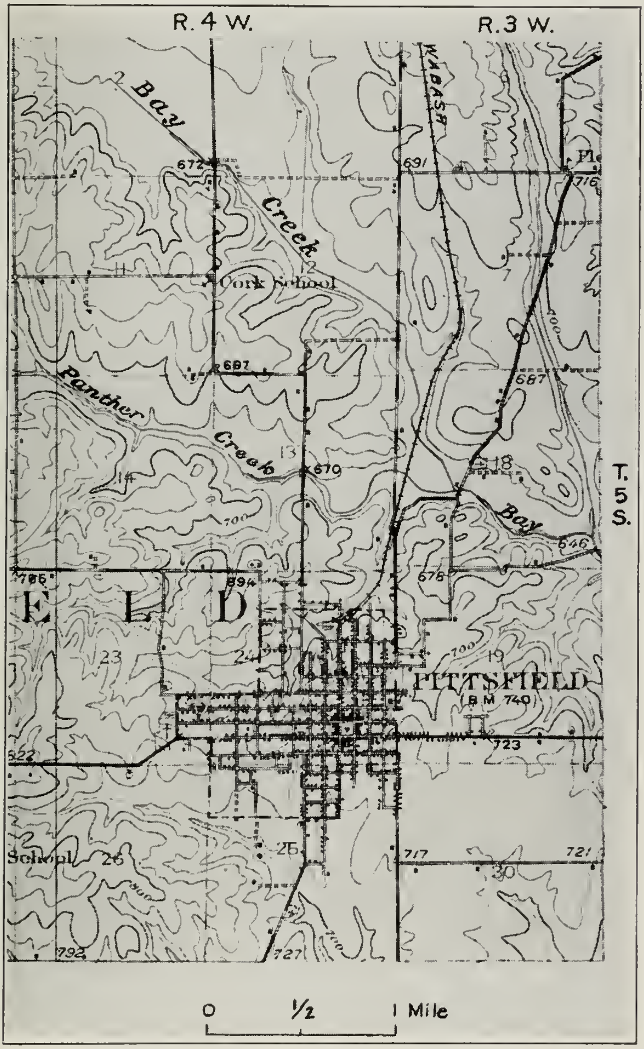

FIG. 5. Topographic map of Pittsfield and vicinity. (Part of Pittsfield quadrangle map.)

GEOLOGY

The clay of the Pittsfield area is probably a part of the Cheltenham member of the Pennsylvanian system, and appears to be roughly the stratigraphic equivalent of the Calhoun County clays. No data are available to determine whether or not the clays of the Pittsfield area occur in ancient sinks, although it is known that a few miles farther east Pennsylvanian sediments do occur in this fashion.

Ceramic Properties

The results of tests on two samples of clay from the Pittsfield area indicate that the clay is suited for the manufacture of building brick, stove tile, stoneware, architectural terra cotta, sanitary ware, quarry tile, and for use as a plastic bond for refractories (Samples T and U). Because they are refractory, the clays are not well adapted for use in making light weight, burned clay aggregate by processes now used commercially.

Table 7.—*Results of tests on clay in the Pittsfield area*

Sample T

Two miles north of Pittsfield [a]

This is a soft clay, colored yellow to dark brown. A fair degree of plasticity may be developed.

Water of plasticity	*per cent*	27
Shrinkage water	*per cent*	13.5
Pore water	*per cent*	13.5
Modulus of rupture	*lbs. per sq. in.*	414.5
Slaking test, average	*minutes*	11

Screen test:

Mesh	Residue *Per cent*	Character of residue
20	0.08	Rock particles and organic matter
40	Trace	....
60	Trace	....
80	Trace	....
120	0.79	White sand and rootlets
200	1.32	White sand and rootlets

Drying shrinkage:

Linear; dry length	*per cent*	8.2
Volume	*per cent*	24.5

[a] Parmelee, C. W., and Schroyer, C. R., Further Investigations of Illinois Fire Clays, Illinois Geol. Survey Bull. 38D, p. 101, 1921.

Burning test:

Cone	Burning shrinkage *Per cent*	Porosity *Per cent*	Color	Remarks
02	4.9	17	cream	....
2	5.1	14	cream	....
3	5.8	12	medium cream	Smooth fracture; fine iron specks (?); none on another trial piece.
6	6.2	6	medium cream	Smooth fracture; fine iron specks (?); none on another trial piece.
				Somewhat conchoidal fracture.
9	6.3	1.2	stoneware gray	Vitreous.
12	5.0	1.0	gray white	Fine veining of iron stain; good color.
13	4.5	1.6	gray white	....
15	4.5	3.8	gray white	Fine iron spots.

Fusion test: Deformed at cone 29 (approximately 2984° F.)

Summary

The sample is a clay of medium high strength which has a medium drying shrinkage. The total shrinkage at cone 9 is medium high. Vitrification is practically complete between cones 6 and 9. There are some indications of overburning at cone 15. It is a refractory clay.

Suggested uses: Stoneware, architectural terra cotta, sanitary ware, a plastic bond clay for refractories.

Sample U

Outcrop along Honey Creek N. ½ sec. 26, T. 5 S., R. 4 W.[a]

Kind of material..Clay
Drying conduct..Good
Volume drying shrinkage..................................*per cent* 20.20
Linear drying shrinkage ....*per cent* 7.24
Water of plasticity..*per cent* 27.00
Bonding strength—Modulus of rupture.....................*lbs. per sq. in.* 357.8
Bulk specific gravity.. 1.89
Screen test:

Mesh	Residue *Per Cent*
28	0.9
48	3.2
65	1.5
100	0.7
200	1.1

[a] Test made by Ceramic Engineering Department, University of Illinois, for the Illinois State Geological Survey.

Burning test:

Cone	Burning shrinkage		Porosity *Per cent*	Color	Fracture
	Volume *Per cent*	Linear *Per cent*			
02	11.79	4.10	19.25	salmon pink	granular
2	11.95	4.15	20.04	tan	granular
3	14.45	5.07	13.73	tan	granular
6	13.88	4.86	14.00	tan	granular
7½	18.38	3.95	13.84	light tan	granular
10	19.38	6.93	9.53	tan	granular
11	21.21	7.64	9.25	bluestoned	granular

Fusion (Deformation) test: P.C.E., Cone 26 (approximately 2903° F.)
Oxidizing conduct: medium

Summary

Drying shrinkage, medium; bonding strength, medium; vitrification incomplete at cone 11; shrinkage at cone 11 is medium low. It is nonrefractory.

Suggested uses: Building brick, stove tile, possibly flue linings, architectural terra cotta, sanitary ware, quarry tile, and roofing tile.

Possibilities of Development

The data suggest that extensive areas in the vicinity of Pittsfield are underlain by clays which appear to be potential sources of good ceramic materials, but the distribution and character of the deposits are not well known. The topography of the Pittsfield area with its relatively broad upland flats is generally favorable to development of large pits, but all of the area except that portion lying north of Pittsfield, which is served by a branch line of the Wabash Railroad, is without railroad transportation. Drilling and thorough testing to ascertain the extent and character of the deposit should be made before extensive exploitation of any given deposit is undertaken.

SIXMILE CREEK AREA

Location and Occurrence

A test pit dug at the head of a north-south ravine in the range of hills lying east of Sixmile Creek in the SE. corner of the NW. ¼ NE. ¼ sec. 5, T. 7 S., R. 4 W., about 2½ miles north of Pleasant Hill, shows the following geologic section:

	Thickness *Feet*
4. Loess	6+
3. Gravel, chert in a clay matrix	1
2. Clay, red	1—3
1. Clay, mostly yellow but mottled with gray	5½
Covered	

The pit is about 25 feet below the top of the ridge and the exposed clay is obviously contaminated with overlying material. Where fresh it will probably be found to be gray, without the yellow iron-stain which has evidently been introduced from the overlying sediments. The red clay and overlying chert gravel are similar to the section found above the clay in the Howell Hollow area in Calhoun County, and the general character of the yellow clay also resembles the clays of that area. The bedrock core of the hill is Burlington limestone.

FIG. 6. Topographic map of Sixmile Creek area, showing location of prospect pit. (Part of Nebo quadrangle map.)

CERAMIC PROPERTIES

The results of tests on a sample of clay (Table 8, Sample V) taken from the test pit show that the clay is not of as high quality as that in the Howell Hollow area, which might be expected, as the sample was more or less contaminated, but they suggest that it may compare favorably and indicate certainly that the Sixmile Creek area is worthy of further prospecting.

TABLE 8.—*Results of tests on clay from Sixmile Creek area*

Sample V

Test Pit, NE. ¼ sec. 5, T. 6 S., R. 4 W.[a]

Kind of material		Clay
Reaction for carbonates		Present
Reaction for pyrites		None
Color		Dark buff
Hardness		Medium
Working property		Good
Conduct when flowing through a die		Satisfactory
Drying conduct		Scums a little in drying. No warping or cracking
Volume shrinkage	*per cent*	32.0
Linear shrinkage	*per cent*	9.7
Water of plasticity	*per cent*	27.8
Shrinkage water	*per cent*	16.2
Pore water	*per cent*	11.6
Transverse strength tests of unburned clay		
Modulus of rupture with 50 per cent standard sand		
Lbs. per sq. in.		259
Number of briquettes		13
Modulus of rupture without sand		
Lbs. per sq. in.		440
Number of briquettes		13

Fineness test:

Mesh	Residue *Per cent*	Character of residue
10	0.1	Pebbly
20	0.1	Pebbly
48	0.2	Micaceous, sandy
100	0.6	Micaceous, sandy
200	5.8	Micaceous, sandy
Through 200	93.2	

Burning test:

Cone	Burning shrinkage		Total Shrinkage Linear *Per cent*	Porosity *Per cent*	Color	Hardness
	Linear *Per cent*	Volume *Per cent*				
2	4.7	13.4	14.4	16.7	very light tan	almost steel hard steel hard
4	5.7	16.1	15.4	12.5	buff	steel hard
6	6.1	17.3	15.8	11.4	tan	steel hard
8	6.3	17.8	16.0	9.7	tan	steel hard
10	7.1	19.7	16.8	5.9	gray	steel hard
12	7.5	20.9	17.2	4.1	gray	steel hard
13	4.5	12.8	14.2	11.5	gray	(fused lime spots)

[a] Tests made by Ceramic Engineering Department, University of Illinois, for Illinois State Geological Survey.

Oxidation conduct .... Easily oxidized
Soluble sulfates.. Present—small amount
Warpage .... None
Fusion (Deformation) Test: P.C.E., cone 23-26 (approximately 2876°—2903°F.).
Suggested uses: Light colored brick; flue linings; conduit; terra cotta; stoneware.
Remarks: Good burning range, cones 4-8 inclusive; overburned above cone 12.

Possibilities of Development

The Sixmile Creek exposure in itself does not demonstrate the existence of a commercially valuable deposit of clay in the area, but it encourages prospecting to ascertain if this is so. It suggests further that additional clay deposits may be found in favorable places between the Howell Hollow area in Calhoun County and the Sixmile Creek area. In searching for clays in this region, prospecting would probably be most advantageous on the higher hills of the region, particularly those having an elevation of 725 feet or more. Test borings are recommended especially in the central portions of the ridges. Exploratory work along the sides of the hills is most likely to reveal clay at elevations above 665 feet.